IOWA TORNADOES

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[Manuscript received January 15, 1962; revised May 29, 1962]

ABSTRACT

The climatology of Iowa tornadoes, prepared to consolidate and update these data for effective public service use, research, and other applications to the State's economy, is based on the 667 reported incidences from 1916 through 1960. But some comparison with earlier record is made since many of the outstanding tornadoes and most of the heavy losses of life occurred from 1859 through 1918. The outstanding tornadoes are grouped in the following classes: (1) with path length 25 miles or longer, (2) property loss of a quarter million dollars or more, and (3) those with outstanding loss of life and property.

The Iowa tornado climatology agrees broadly with the characteristics of tornadoes in the United States as a whole. However, the areal, seasonal, and diurnal distributions for Iowa are refined, thereby increasing the useful knowledge for regional use.

1. INTRODUCTION

Iowa, located immediately northeast of the heart of the world's most destructive tornado zone (fig. 1), now ranks fourth among all the States of the Nation in the total number of tornadoes recorded since 1916. Iowa led the Nation in reporting the greatest annual number of tornadoes during 13 of the 27 years from 1918 through 1944, but since 1944 Iowa has ranked comparatively lower, as other States in the tornado belt have reported increasing numbers of tornadoes [7]. Iowa's long-term annual mean varied only slightly after 1944 as compared to the 1916–44 average. This may simply indicate more complete and homogeneous reporting in Iowa than in many of the other States of the tornado belt.[1] Fortunately, tornado deaths have been comparatively light since 1918, with only 61 persons killed in the past 42 years. However, Iowa tornadoes have not always occurred in thinly populated areas and from time to time through 1918 considerable losses of life were reported. The two greatest tornado calamities of authenticated record occurred in 1882 and 1893 with loss of life of at least 100 and 89 persons, respectively. To the Camanche tornado [4, 10, 21] 134 deaths were attributed although accounts vary. Since there seems to be no decrease in the frequency or intensity of tornadoes in recent years it can be concluded that in the face of an increasing population, Iowa has been fortunate to have had so little loss of life and no major metropolitan areas struck by a well-developed tornado. During the 1890–1915 period, the 49 tornadoes recorded caused a death toll of 239 persons which is about 11 times the loss of life that occurred in the latest 26-year period of record (1935–60) when 21 persons died in tornadoes. However, during the 1890–1915 period the average number of tornadoes recorded per year was less than 2 as contrasted to about 15 per year during the 1916–60 period; it is quite possible, and very probable, that the average annual number of tornadoes in Iowa is some number quite in excess of 15.

A tabulation of Iowa tornadoes chronologically from 1890 through 1960 with associated loss statistics [22] and a chronological cross-index of tornadoes by county of origin [12] were originally prepared because of public service requirements upon U.S. Weather Bureau offices and other agencies concerned with the State's public safety and welfare. From these data, omitting the few tornadoes reported prior to 1916, were prepared the Iowa tornado statistical summarizations of this paper. But the period prior to 1916 was not entirely neglected (table 5) because of the several tornado calamities that gained Iowa a reputation for tornadoes well before the 20th century, although Hinrichs [6] dissented. In some States tornado calamities have directed public attention toward the incorporation of safety features into such construction as schools and factories. The data included in this paper provide seasonal and areal probabilities for these uses as well as for radar meteorological research and the improvement of severe storm forecasting. In 1953, Flora [2] reported more tornadoes per unit area in Iowa than in any other State in the union, but the reporting intensity center has since shifted southwestward (fig.1). Nevertheless, the need for adequate preparation in the event of a tornado strike has been historically demonstrated. The climatological data about tornadoes now available for intelligent planning provide the probability basis for these considerations.

A certain amount of bias is evident in these data, as in those for any area, because of the uneven distribution of human population and related interest and indirectly, perhaps, the distance from the collection center. Classi-

[1] Considerable credit for a large portion of the excellent record is due Mr. C. D. Reed, Iowa Section Director 1918–44 and S. E. Decker whose comprehensive summaries in *Climatological Data, Iowa* provided valuable source material.

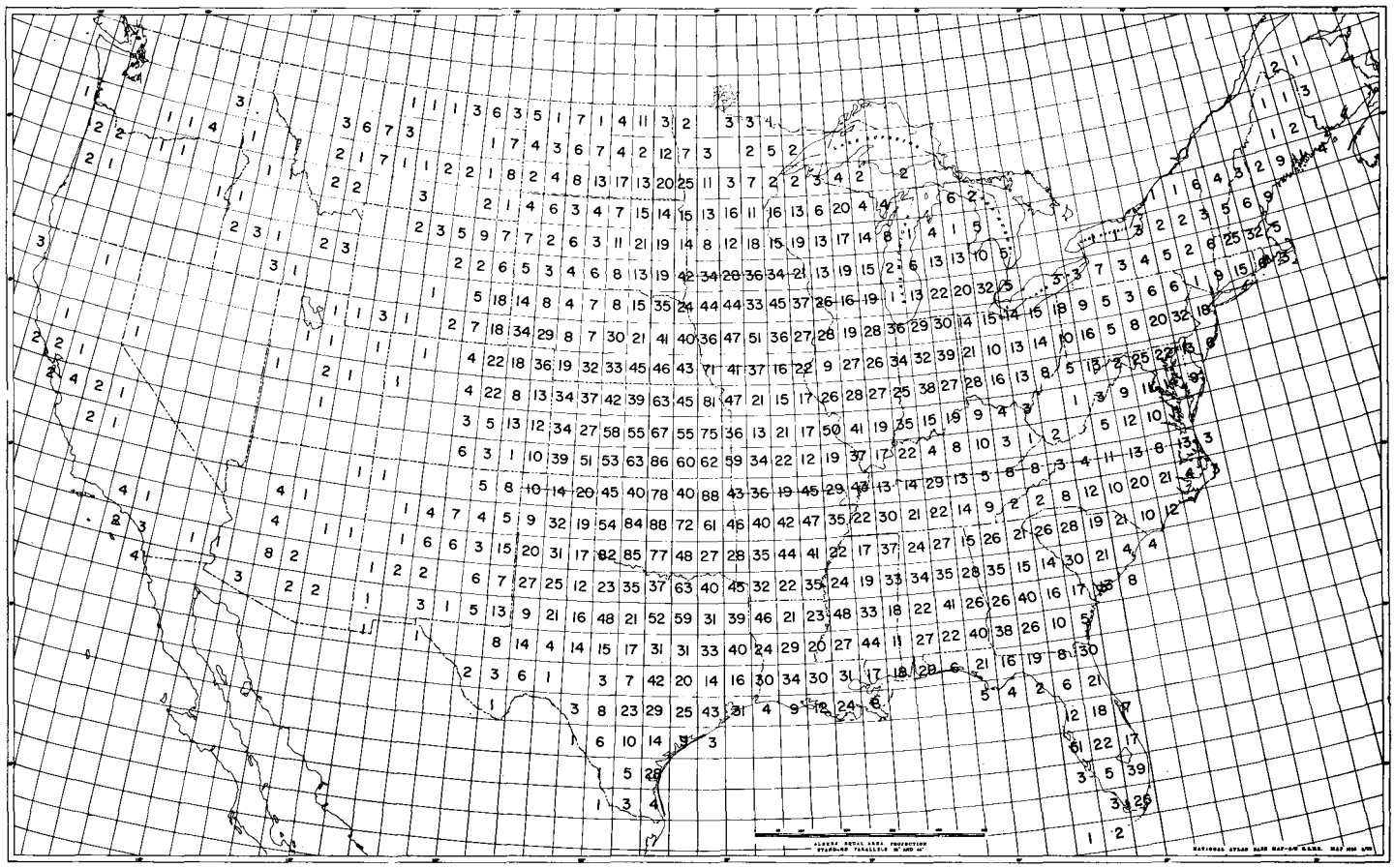

FIGURE 1.—Number of reported tornadoes in the United States by 1° "squares", 1916–61 [20]. Based on the first point of contact with ground of 11,053 tornadoes.

fication of the tornadoes does not wholly eliminate these biases and indicates certain other limitations of the storm statistics such as the variable classification of tornadoes passing over State borders and those occurring in family groups.

2. SOURCES AND RELIABILITY OF DATA

The Iowa tornado tabulation 1890–1960 [22] was prepared from the tornadoes officially recorded in Weather Bureau publications [15, 16, 17, 18]. Additional data about Iowa tornadoes were available from the original newspaper accounts of some of the tornadoes and from Yearbooks and Annual Reports of the Iowa Crop and Weather Service (1890–1959). The data have been carefully compared with a recently revised Weather Bureau study [14]. Where supplementary data were available, revisions or new tornado entries were made, but few changes were necessary despite the supplementary data sources. It is inevitable that some tornadoes have been omitted and some others improperly classified. Tornadoes with long paths and those with skipping paths may have been reported as several with shorter paths, even though these may have been generated at intervals from a single parent cloud. Nevertheless, these tornado data have been carefully evaluated by the various meteorologists and climatologists over the years and are the best available. The characteristic pattern of destruction has been well known in Iowa since settlement began in the State, with some authenticated tornado records extending over a full century. Early newspapers, and historical accounts in such publications as the *Palimpsest* and the *Iowa Weather Report* [16] have provided the information about the earliest tornadoes reported in Iowa [3, 9, 10, 11, 21, 23].

3. IOWA TORNADO CHARACTERISTICS

Tornadoes in Iowa differ little from the violently revolving funnel clouds so well known east of the Rockies in the United States, in south and central Russia, and in southern Australia, but are more frequent and intense than those occurring elsewhere in the United States or Europe, Asia, and Africa. In the 1916–60 period, Iowa reported a total of 667 tornadoes, approximately one-sixteenth of the nationwide count of 10,340 tornadoes. The areal distribution of Iowa tornadoes by county point of origin indicates a higher frequency over most of western and central Iowa than elsewhere in the State (fig. 2).

The average number of tornadoes per season is 14.8,

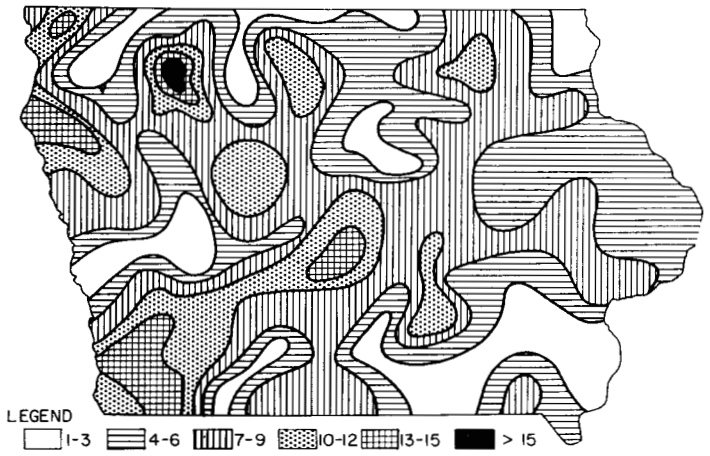

FIGURE 2.—Tornado frequency in Iowa, 1916–60. Isolines based on total number reported per county (approximately per 0.4° "square") of origin.

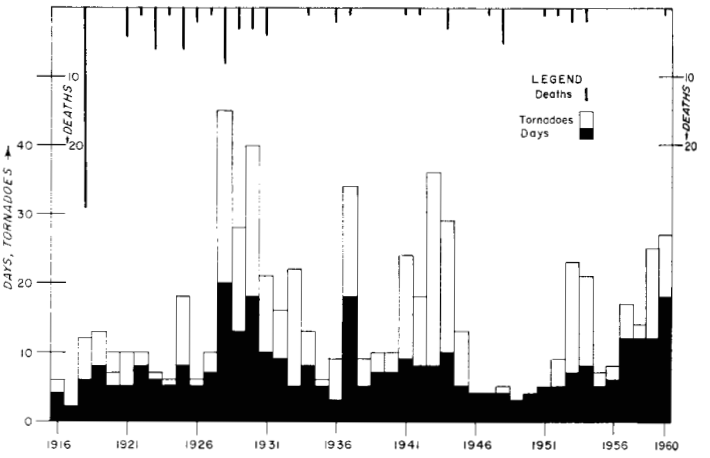

FIGURE 3.—Number of reported tornadoes, tornado days, and tornado deaths in Iowa by years, 1916–60.

occurring on an average of 7.7 days (table 1 and fig. 3). The seasonal distribution has ranged from 2 tornadoes on 2 days in 1917, to 45 tornadoes on 20 days in 1928. On the average, about 1 tornado each year has caused death, 2.3 have traveled a distance of 25 miles or more, and 1.3 have caused at least a quarter of a million dollars loss (table 2).

TABLE 1.—*Annual number of tornadoes, days, deaths, injuries, and damage in Iowa, 1916–60*

Year	Number	Days	Deaths	Injuries	Damage (thousands $)
1916	6	4	0	0	$110
1917	2	2	0	0	8
1918	12	6	29	183	2,450
1919	13	8	0	0	157
1920	7	5	0	5	198
1921	10	5	4	20	684
1922	10	8	1	6	747
1923	7	6	6	6	95
1924	6	5	1	8	99
1925	18	8	6	58	2,150
1926	6	5	2	29	427
1927	10	7	1	5	168
1928	45	20	8	10	1,970
1929	28	13	3	19	232
1930	40	18	3	30	445
1931	21	10	4	54	478
1932	16	9	0	0	211
1933	22	5	0	1	432
1934	13	8	1	3	449
1935	6	5	0	0	169
1936	9	3	2	36	662
1937	34	18	1	10	396
1938	9	5	0	6	42
1939	10	7	0	9	196
1940	11	8	0	27	134
1941	24	9	1	9	512
1942	18	8	1	13	471
1943	36	8	0	20	865
1944	29	10	3	31	2,204
1945	13	5	0	10	245
1946	4	4	0	4	500
1947	4	4	1	3	350
1948	5	4	5	27	1,025
1949	3	3	0	4	230
1950	4	4	0	5	59
1951	5	5	1	17	6,730
1952	9	5	1	4	1,210
1953	23	7	2	19	3,315
1954	21	8	2	12	1,902
1955	7	5	0	0	91
1956	8	6	0	9	523
1957	17	12	0	1	257
1958	14	12	0	2	190
1959	25	12	0	11	(*)
1960	27	18	1	5	(*)
Total	667	347	90	731	
Average	14.8	7.7	2.0	16.2	

*Losses categorized by classes.

TABLE 2.—*Special tornado classes. Annual number tornadoes causing death and injury, death only, $250,000 or greater loss, and path lengths of 25 miles or longer, 1916–1960*

Year	Deaths and injuries	Deaths only	$250,000 or greater loss	Path 25 miles or longer
1916	0	0	0	1
1917	0	0	0	0
1918	9	7	4	6
1919	0	0	0	0
1920	2	0	0	0
1921	3	2	1	1
1922	1	1	1	2
1923	2	1	0	0
1924	4	1	0	0
1925	8	4	3	2
1926	2	1	1	0
1927	3	1	0	0
1928	9	4	2	4
1929	7	3	0	1
1930	7	2	0	0
1931	5	3	0	1
1932	0	0	0	2
1933	1	0	1	2
1934	3	1	1	2
1935	0	0	0	0
1936	2	1	2	1
1937	5	1	0	1
1938	2	0	0	0
1939	5	0	0	1
1940	3	0	0	0
1941	3	1	0	8
1942	4	1	1	4
1943	8	0	1	4
1944	5	2	1	3
1945	3	0	0	3
1946	1	0	1	1
1947	2	1	1	1
1948	3	1	3	1
1949	1	0	0	0
1950	1	0	0	0
1951	3	1	2	0
1952	2	1	0	1
1953	8	2	3	5
1954	4	2	2	3
1955	0	0	0	0
1956	2	0	1	1
1957	1	0	0	1
1958	2	0	0	2
1959	3	0	5	1
1960	1	1	1	2
Total	140	46	38	69
Average	3.1	1.0	1.3	2.3

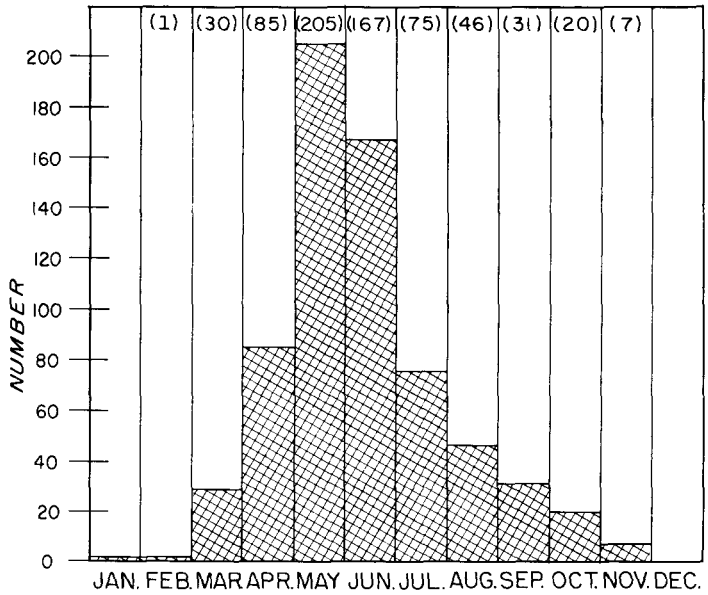

FIGURE 4.—Number of reported tornadoes in Iowa by months, 1916–60.

The seasonal tornado distribution in Iowa, as in the Nation, reaches its peak frequency in May (fig. 4), and tornado days peak in June. Unlike the national distribution, the Iowa seasonal distribution of tornado occurrences is much more pronounced, ranging from none in December and January to 56 percent of the seasonal total in May and June, as contrasted to the national range of 4 percent to 40 percent for corresponding periods. In Iowa, the tornado frequency by months in descending order is (fig. 4): May, 31 percent; June, 25 percent; April, 13 percent; July, 11 percent; August, 7 percent; September, 5 percent; March, 4 percent; October, 3 percent; November, 1 percent; February, a single occurrence; and December and January, none. In the past 45 years, tornadoes occurred on 92 days in June as compared to 81 days in May with an average of 1.8 and 2.5 tornadoes per tornado day respectively. July, with a total of 50 tornado days in the 45 years of record, averages 1.5 tornadoes per tornado day; April with 41 tornado days averages 2.1; August with 32 days averages 1.4; March and September, each with 17 days, average 1.7 and 1.8 tornadoes per tornado day, respectively; October with 11 days averages 1.8; and November with 5 days averages 1.6 tornadoes per tornado day. Thus, tornadoes seem to be more likely on any June day than on a May day, but about 40 percent more tornadoes occur on an outbreak in May as compared to June. The climatological expectancy of tornado days in Iowa in June during any year is then slightly more than 2, with the average June total number of tornadoes slightly under 4—similarly in May it is 1.8 days and 4.5 tornadoes per year.

The peak of the tornado season in Iowa is in late May with the highest actual daily count of 20 tornadoes on May 18 and 21 and the 5-day smoothed mean of 11 on May 19–20 (fig. 5). This coincides with the third most

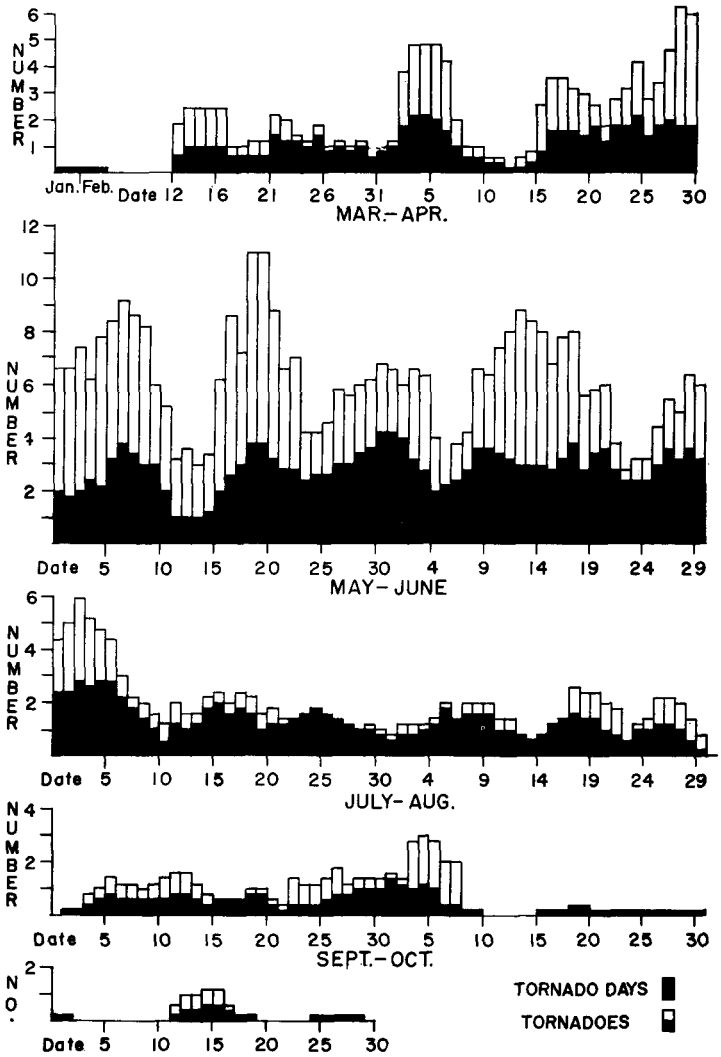

FIGURE 5.—Five-day running means of daily total number of reported tornadoes and tornado days in Iowa, 1916–60.

frequent date nationally on May 20 [14]. The national peak precedes the Iowa peak by 3 weeks. The 5-day smoothed means of daily tornado counts plotted on the center day produced an apparent fluctuation variable mostly from 4 to 7 days from each maximum to minimum and conversely. The correlation of this fluctuation with the national tornado statistics [14] was not particularly good. A similar comparison with warm season rainfall probabilities in Iowa was equally unpromising.

The tabulation of tornadoes over the 60 minutes of each hour (fig. 6) shows that the most likely time of tornado occurrence is around 5:30 p.m. CST. Sixty percent of the Iowa tornadoes were reported between the hours of 2:01 p.m. and 8:00 p.m., but only 1 in 20 between 6:01 a.m. and 12 noon.

Tornado movement (or translation) speeds vary, but average around 40 m.p.h. with the direction of movement usually toward the northeast. In fact, 56 percent of the Iowa tornadoes have moved northeastward and 90 percent in some eastward direction (fig. 7). Of the remaining

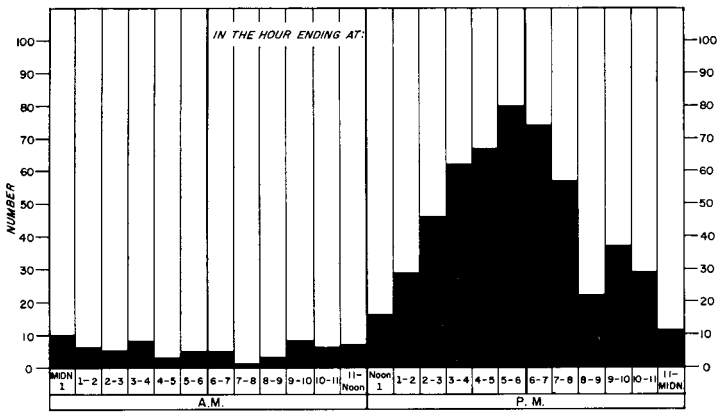

FIGURE 6.—Number of reported tornadoes in Iowa by time of occurrence, 1916–60. Hourly tabulations begin 1 minute past the hour and end on the hour.

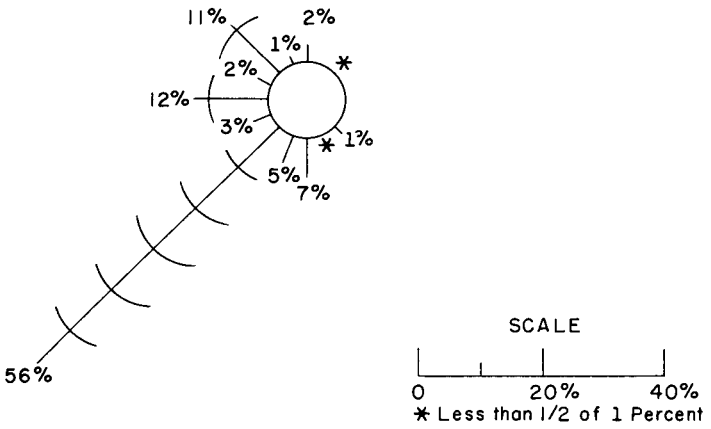

FIGURE 7.—Tornado rose for Iowa, 1916–60, showing percent of reported tornadoes moving from indicated directions.

10 percent, 7 percent moved northward, 2 percent southward, 1 percent northwestward, and a few southwestward and north-northwestward. On at least two occasions, Iowa tornadoes have followed a loop path and on several occasions waterspouts have been reported because of tornado passage over water surfaces.

It is readily apparent upon examination of tornado data that considerable subjectivity is involved. Since the tornado statistics were dependent upon (1) the initial observations, (2) the reporting of the observations to proper authorities, and (3) their classification of wind storms as tornadoes or "not tornadoes", there is, without question, a suggestion of population bias, variable Weather Bureau emphasis and initiative on securing tornado reports, and the individual judgement involved in the final classification.

Because of the possible reporting biases it appeared that tabulations and evaluations under different criteria for classifying outstanding tornadoes would be useful derived tornado statistics. Accordingly, the outstanding

TABLE 3.—*Tornado paths 25 miles or longer, 1916–1960 (see fig. 8)*

Number	Date	Location	Length (miles)
1	1916, Sept. 26	Blanchard to Redding	48
2	1918, May 9	Pearl Rock to Calmar	54
3	May 9	Conesville to Eldridge	42
4	May 21	Denison to Stanhope	69
5	May 21	Berkley to Wellsburg	67
6	May 21	Prairie City to Tama	41
7	May 31	Britt to Silver Lake	32
8	1921, Mar. 26	Arthur to Fonda	28
9	1922, Apr. 10	Athelstan to Creston	40
10	July 16	Gowrie to Newton	76
11	1925, June 2	Glenwood thru Silver City into Shelby Co	45
12	June 2	Onawa to Cushing	46
13	1928, May 2	SW Cherokee Co. to NW Buena Vista Co	40
14	Aug. 26	Red Oak to Greenfield	45
15	Oct. 4	Deep River to Lowden	90
16	Nov. 14	Vinton to Manchester	33
17	1929, Apr. 6	Valeria to Laurel	25
18	1931, Sept. 21	Lick Creek Twp. (Van Buren Co.) to Oregon Twp. (Louisa Co.).	50
19	1932, July 6	Galva to Douglas	180
20	July 9	Ellsworth to High Lake (Emmet Co.)	110
21	1933, July 1	Near Dows and Clarion (Wright Co.)	25
22	July 7	Buena Vista Co	25
23	1934, July 5	Prairie City (Jasper Co.)	30
24	July 10	West Union to Elkader	25
25	1936, June 29	Wilton Junction to Clinton Co	40
26	1937, May 18	E of Spirit Lake to SE of Roland	125
27	1939, Aug. 10	SW of Osceola to near Milo	35
28	1941, Apr. 17	S. Jefferson Twp. (Poweshiek Co.) to Anamosa	60
29	Apr. 18	SW Randolph to W of Wales*	25
30	Apr. 18	SW Malvern to NE Carson*	25
31	Apr. 18	S of Guthrie Center to near Berkley	30
32	Apr. 19	Washington to Andrew	80
33	Sept. 7	NE Prairie City to Ewart	30
34	Oct. 6	Near Bedford to near Osceola	60
35	Oct. 6	SW Ringgold Co. to near Osceola	60
36	1942, May 30	W of Sibley, near Lake Park into Minn	35
37	June 15	Dallas Co. to E of Grimes	30
38	June 28	Guthrie Center to near Madrid	50
39	June 28	NW of Des Moines to Marshalltown	40
40	1943, Mar. 15	Nrn border Madison Co. to E of Grimes	30
41	May 5	E of Colo to Grundy Co	28
42	May 15	SW Hamburg to NE Red Oak	50
43	May 15	Tingley to Osceola	30
44	1944, May 18	From Nebraska into Monona Co	28
45	May 18	Greene, Boone, Webster, & Hamilton Co	30
46	July 14	SE Swea Twp. (Kossuth Co.) to Winnebago Co	25
47	1945, Mar. 16	1W Kanawha to W. Kensett	50
48	Mar. 24	Nashua to Chickasaw Co	30
49	May 21	Villisca to Massena	45
50	1946, May 30	Creston to Lucas Co	40
51	1947, Apr. 29	Entered Iowa E of Pleasanton to Wayne Co	30
52	1948, June 22	Fremont and Mills Co	30–35
53	1952, June 23	Across northern Cherokee Co	30
54	1953, May 10	5SW Ventura to 8W Northwood	28
55	May 20	NW Gilbert to Lime Springs	120
56	May 20	Cedar Rapids to Wyoming	72
57	June 7	Westfield (family of 5 tornadoes)	70
58	June 7	Carson to SE Linn Co	100
59	1954, Apr. 30	From vicinity Sturgeon, Mo. to 3SW Lowden	180
60	Apr. 30	Linn Co. to Wine's Landing	85
61	Apr. 30	Extreme SE Iowa Co. to 1E Delaware	70
62	1956, Aug. 12	Polk Co. to Iowa Co	80
63	1957, July 4	Ida Co. to Iowa Co	150
64	1958, Apr. 5	Near Oto to beyond Hospers	50
65	June 22	Greene, Dallas, and Decatur Co	80
66	1959, May 10	Adair and Boone Co	50
67	1960, Apr. 16	Grundy Co. to Buchanan Co	35
68	May 5	Near Scranton	25

**Climatological Data, Iowa*, May 1941.

tornadoes for loss of human life and injuries, damage of a quarter of a million dollars or more, and tornadoes with path length of 25 miles or longer were separately tabulated (tables 3, 4, 5, and fig. 8) in the hope that these might furnish a more unbiased tornado climatology, since such outstanding tornadoes could scarely escape observation, reporting, or classification. (This, of course, is with exception as examination of historical record reveals.) Of all reported tornadoes 9.6 percent had path length 25 miles or longer, 5.7 percent caused damage of $250,000 or more, 6.9 percent were responsible for loss of human life, and another 14.1 percent caused injuries without record of loss of life. Thus 21 percent of all tornadoes reported in this 45-year period caused human injury or loss of life.

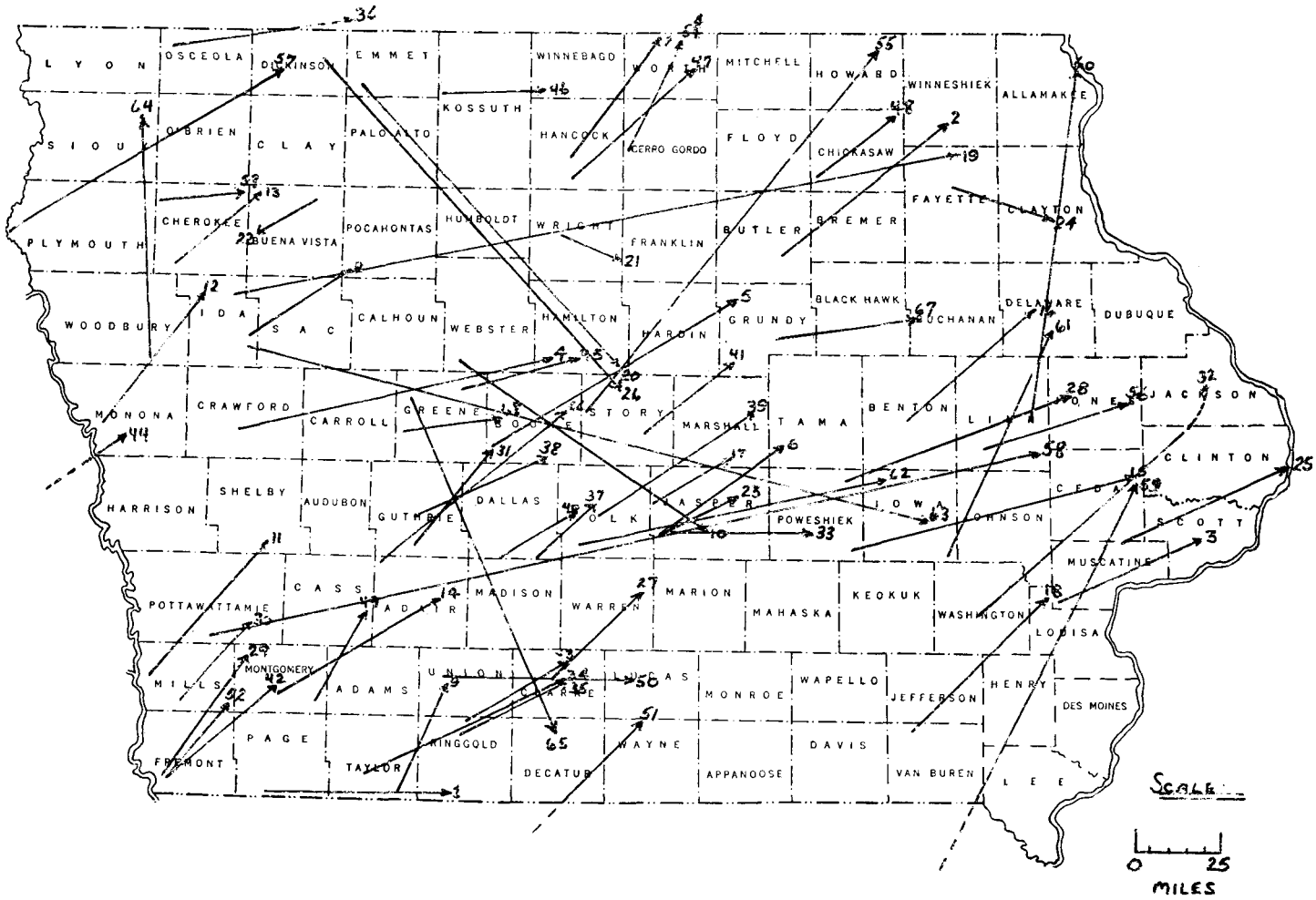

FIGURE 8.—Tornado paths whose length was 25 miles or longer, 1916–60. The numbers at the arrow heads correspond to the sequence of numbers in table 3.

TABLE 4.—*Iowa tornadoes with $250,000 or greater damage (1916–60)*

Date	Location (county of origin)	Loss*	Date	Location (county of origin)	Loss*
1918, May 9	Winneshiek	$500,000	1947, June 9	Plymouth	$250,000
May 21	Crawford	492,000	1948, Apr. 23	Chickasaw	250,000
May 21	Boone	897,980	June 22	Fremont	250,000
May 21	Jasper	350,000	June 29	Dubuque	250,000
1921, May 26	Cerro Gordo	300,000	1951, June 1	Marshall	600,000
1922, July 16	Webster	500,000	June 25	Hancock	**4,500,000
1925, June 2	Monona	480,000	1952, June 23	Cherokee	1,000,000
June 3	Pottawattamie.	750,000	1953, May 10	Cerro Gordo	1,000,000
			May 20	Linn	300,000
June 11	Franklin	350,000	June 7	Plymouth	1,350,000
1926, June 16	Page	250,000	1954, Apr. 5	Page	318,000
1928, May 2	Cherokee	350,000	Apr. 30	Van Buren	1,240,000
Aug. 26	Montgomery	400,000	1956, Aug. 12	Poweshiek	1,050,000
1933, July 1	Wright	300,000	1957, July 4	Ida	700,000
1934, June 20	Cass	300,000	1959, May 9	Jefferson	250,000
1936, Apr. 30	Clay	305,000	May 9	Van Buren	350,000
Apr. 30	Emmet	285,000	May 10	Adair	685,000
1942, June 15	Buchanan	250,000	May 18	Adams	250,000
1943, Mar. 15	Buchanan	250,000	May 31	Story	300,000
1944, June 16	Sioux	1,000,000	1960, Apr. 16	Grundy	†500,000
1946, May 30	Union	450,000			

*Based on monetary values at time of occurrence.
**Includes extensive flood damage.
†Greater than $500,000 loss.

Even these criteria have their limitations. The number of tornadoes causing a quarter million dollars or greater loss fluctuates more or less directly with the price index such that the fewest occurred during the depression years in the '30s and the number increased thereafter. Tornadoes causing death have diminished with time in relation to the total population, most likely because of improved forecasting, warning, and communication facilities, but also due to a greater number of "lesser" tornadoes being reported with more chance of visual sightings. In the 1916–30 period, 27 tornadoes of the 220 reported caused death, a ratio of nearly 1 in every 8, as compared to 10 death-causing tornadoes of the 271 reported in the following 15 years (1931–45), and 9 out of 176 reported in the 1946–60 period.

By 5-year intervals, tornadoes of 25 miles or longer have varied from a frequency of 22 in the 1941–45 period to 3 in 1946–50 and 1936–40. In general, figures 1, 2, and 8 are in agreement, although figures 2 and 8 refine the total population to densities within the State. A concentration of tornadoes reported in Clay County on figure 2 is curiously absent in figure 8, since no reported tornado of

TABLE 5.—*Some outstanding Iowa tornadoes (1859–1960)*

No.	Location	Date	Time of occurrence	Killed	Injured	Property* damage
1	Near Iowa City	May 24, 1859	Aftn.	5	18	$12,000
2	Camanche	June 3, 1860	6:30 p.	134	81	2,500 homeless
3	Keokuk and Washington Co	May 22, 1873	2:00 p.	8	15	
4	Monona Co. to Buena Vista Co	Apr. 21, 1878	4:00 p.	10	28	$100,000
5	Crawford Co. to Pocahontas Co	Apr. 21, 1878	4:40 p.	18	29	$100,000
6	Monticello	Oct. 8, 1878	5:30 p.	0	0	$100,000
7	Macedonia	June 9, 1880	Evening	Many	----------	Heavy
8	Grinnell	June 17, 1882	8:45 p.	100	----------	$1,000,000
9	Coon Rapids	Apr. 14, 1886	3:00 p.	Destroyed much of Coon Rapids		
10	Pomeroy	July 6, 1893	5:00 p.	89	----------	$225,000
11	Clay Co	Sept. 21, 1894	5:00 p.	53	----------	
12	Sioux Co	May 3, 1895	3:20 p.	15	35	
13	Polk Co. to Jasper Co	May 24, 1896	9:30 p.	20	----------	$75,000
14	Stanwood	May 18, 1898	3:00 p.	19	40	$400,000
15	Harlan	Mar. 23, 1913	6:00 p.	33	100	$1,000,000
16	Pearl Rock to Calmar	May 9, 1918	4:00 p.	8	20	$500,000
17	Denison to Stanhope	May 21, 1918	2:15 p.	6	35	$492,000
18	Berkley to Wellsburg	May 21, 1918	3:45 p.	10	91	$897,980
19	Council Bluffs	Sept. 28, 1923	7:50 p.	6	5	$15,000
20	Sioux County	June 16, 1944	7:00 p.	0	0	$1,000,000
21	Ionia (Chickasaw Co.)	Apr. 23, 1948	3:25 p.	5	25	$250,000
22	Marshalltown	June 1, 1951	9:15 p.	0	7	$600,000
23	Duncan to Crystal Lake	June 25, 1951	5:07 p.	1	8	$4,500,000**
24	Near Ventura	May 10, 1953	4:10 p.	0	3	$1,000,000
25	Plymouth Co. to Hamilton Co	June 7, 1953	6:15 p.	0	0	$1,350,000
26	Van Buren Co. to Cedar Co	Apr. 30, 1954	3:15 p.	1	9	$1,240,000
27	Polk Co. to Iowa Co	Aug. 12, 1956	2:30 p.	0	8	$1,050,000
28	Ida Co. to Iowa Co	July 4, 1957	2:28 a.	0	1	$700,000
29	Van Buren Co	May 10, 1959	1:00 p.	0	0	$685,000
30	Grundy Co. to Buchanan Co	Apr. 16, 1960	2:30 p.	1	5	$500,000†

*Losses based on monetary values at time of occurrence.
**Includes extensive flood damage.
†Greater than $500,000 damage.

25 miles or greater length has ever originated in Clay County. Figure 8 also reveals only 4 tornadoes of the total 66 as having traveled over the Iowa border, as contrasted to 33 tornadoes that traveled over the inner border of the tier of counties indicating that perhaps a greater coordination in reporting may be needed between States.

4. SOME NOTEWORTHY IOWA TORNADOES

Tornadoes have been of considerable interest in Iowa, as in all parts of the world, as evidenced by the early written reports and the national and international interest in regard to the outstanding tornado disasters in Iowa that occurred mostly in the latter half of the 19th century.

The earliest tornado of record in Iowa was reported on July 29, 1804 as the Lewis and Clark Expedition [10], toiling up the Missouri River along the present boundaries of southwestern Iowa, observed the destructive work of a tornado that had passed southeastward into Iowa about a year before. Captain William Clark entered in his journal on that date the following:

> On the S.S. passed much falling timber appearently the ravages of a Dreddfull harican which had passed oblequely across the river from N.W. to S.E. about twelve months Sinc, many trees were broken off near the ground the trunks of which were sound and four feet in diameter.

On June 18, 1859, national attention was directed to an Iowa tornado in *Frank Leslie's Illustrated Newspaper* which contained five graphic pen sketches and a brief but vivid account by Mr. J. A. Weatherby of Iowa City of a tornado that passed south of Iowa City in a southeasterly direction on the afternoon of May 24, 1859. The Iowa City *Republican* reported loss of life and property heavy (5 killed, 18 injured, and $12,000 damage). Dr. Gustavus Hinrichs [6], the first Director of the Iowa Weather Service, authenticated this tornado as the first reported tornado in the State after settlement began, although many must have occurred previously that were not reported. Evidence of earlier tornadoes in Shelby County was established by Asp [1].

During the following summer on June 3, 1860, Camanche, Iowa, located 6 miles south of Clinton, was virtually obliterated by a tornado. This disaster was reported as a "national calamity" to the Nation in *Harpers Weekly* [4]. Accounts of the loss of life and damages vary. Dorothy Wagner [21] tabulated the loss of life at 134 persons and 2,500 rendered homeless. Another account listed 28 dead, 81 injured, and hundreds homeless after the 100-mile long tornado had passed out of Iowa. The tornado was first seen about 15 miles west of Cedar Rapids during the afternoon of June 3, reaching Camanche about 6:30 p.m.

Apparently the next outstanding tornado disasters were the twin twisters on Easter Sunday (April 21) 1878, described by Dr. Hinrichs [13]. Despite the sparsity of settlement, 28 persons were killed and 57 injured as these tornadoes moved northeastward along the Maple and Boyer Rivers. On this occasion the first waterspout to be reported in Iowa was observed as the Maple River tornado moved across Storm Lake "causing immense waves to beat against the shore" [13].

In the 41-year span, 1878 through 1918, 381 persons lost their lives during 10 outstanding days of tornado action (see table 5) as contrasted to the 66 lives lost in

the latest 41 years of this survey. Thus, it is evident from these and other comparisons that the tornado reputation of Iowa was dramatically formulated mostly in the years before the most complete tornado record gathering years from 1961 to date.

From the list of outstanding tornadoes in table 5, the Grinnell tornado on June 17, 1882 accounted for 100 lives lost, and the Pomeroy tornado on July 6, 1893 accounted for another 89 persons killed. The Grinnell tornado was classified as the most destructive up to that time in Iowa with the heaviest losses in Grinnell and Malcom [2, 6].

J. R. Sage (Iowa Weather and Crop Service, 1893) noted that many lives were spared in the Pomeroy tornado as people took refuge in tornado caves and basements. This tornado orignated in Cherokee County about 5:00 p.m. on July 6, 1893 and moved east-southeastward reaching Pomeroy between 6:30 and 7:00 p.m., and ending about 4 miles east of Pomeroy. This tornado also passed over Storm Lake creating a waterspout and the "water along the north shore receded rapidly, a hundred feet or more, leaving bare ground at the pier where the small steamboat lands. After its passage, water rushed back with a tidal wave several feet high." [13].

The storm of September 21, 1894, to which 53 deaths and a half million dollars loss were attributed, moved from Clay to Howard County. Multiple tornado paths were reported which in most cases were oriented to the northeast as is often the case with many tornadoes of unusual length.

The outstanding losses on March 23, 1913 were again caused by a complex of tornadoes that moved out of Nebraska; losses were mostly concentrated in Shelby County and the adjacent counties.

Of the numerous outstanding tornadoes investigated, the direction of movement ranged from northeast to southeast. Some of the most damaging tornadoes moved southeastward, among which were the Iowa City tornadoes (1859), the Camanche tornado (1860) [4, 21], the Grinnell tornado (1882) [5], and the Pomeroy tornado (1893) [11]. Again in recent years some southeastward moving storms have been outstanding and merit further research.

On two occasions the reported tornadoes were unique in that a circular path was described. On June 23, 1919 at about 6:25 p.m. near Riceville a tornado ". . . made a complete loop and crossed its own path nearly all within Sections 1, 2, and 12 of Douglas Township, as vouched for by many eye witnesses." [19]. In 1942, on June 15, a crescent-shaped tornado path, which curved from a southeasterly direction through the south, west, north, and then northeast, was reported in Buchanan County. Upon occasion tornadoes have been reported to split and in other instances to follow closely in the path of a preceding twister. Tornadoes have been reported to have touched only into the tree tops on occasion, and a large number of funnel clouds are now reported which never reached the ground.

Iowa tornadoes in recent years have been noteworthy primarily because of property losses. Of the 6 tornadoes with at least a million dollar loss (table 4) 5 were reported in the last decade; undoubtedly a result, in part, of the dollar valuation change. The $6 million loss associated with the storm in Hancock County on June 25, 1951, ". . . was largely caused by flooding following widespread rains." [8]. The associated tornado laid waste the small town of Duncan at 5:07 p.m., destroying the largest buildings and damaging numerous homes, then moved northeastward demolishing homesteads and overturning a freight train before spending itself [18].

ACKNOWLEDGMENTS

For the credible collection of Iowa tornado data over the decades we stand indebted to scores of Cooperative Weather Observers, as well as to the meteorologists and climatologists who evaluated these reports. We are particularly indebted to the six directors of the Iowa Weather Division, the latter five also the U.S. Weather Bureau Section Directors; Dr. Gustavus Hinrichs (1873–1890), Mr. J. R. Sage (1890–1907), Dr. George M. Chappel (1907–1918), Mr. C. D. Reed (1918–1944), Mr. H. C. S. Thom (1944–1948), and Mr. C. E. Lamoureux (1948–1954). Since 1954, Weather Bureau State Climatologists Mr. C. R. Elford (1954–1959) and one of the authors, Mr. Paul J. Waite (1959–), evaluated the storm data. To Mr. S. E. Decker we are indebted for many valuable narratives contained in the *Climatological Data, Iowa*. We appreciate the excellent cooperation from the Iowa History and Archives in making historical newspaper accounts available. To Mr. Robert F. Dale, U.S. Weather Bureau Central Area Climatologist, and Mr. C. E. Lamoureux, Meteorologist in Charge, Weather Bureau Airport Station, Des Moines, we are grateful for the careful reading of this paper and many useful suggestions and comments. To the Iowa Weather Division, we are indebted from the beginning of the records in 1875 to the present for the support extended, thereby making possible this paper.

REFERENCES

1. M. O. Asp, "Tornadoes in Shelby County, Iowa," Manuscript, 1955 (unpublished).
2. Snowden D. Flora, *Tornadoes of the United States*, University of Oklahoma Press, Norman, Okla., Rev. 1958.
3. W. W. Gist, "A Story of Devastation (Emmetsburg-Cresco)," *Midland Monthly*, vol. 2, Nov. 1894, pp. 377–384.
4. "The Great Tornado (Camanche)", *Harpers Weekly*, June 23, 1860.
5. S. H. Herrick, "The Grinnell Cyclone of June 17, 1882," *Annals of Iowa*, vol. 3, No. 3, July 1897, pp. 81–96.
6. Gustavus Hinrichs, "Tornadoes in Iowa," *Report of the Iowa Weather Service*, 1888, pp. 289–316.
7. L. A. Joos, "Time Trends in Mid-West Tornado Statistics," Manuscript, 1960 (unpublished).
8. C. E. Lamoureux, Personal communication, 1961.

9. Sgt. James Mackintosh, "The Iowa and Illinois Tornadoes of May 22, 1873," *Report of the Chief Signal Officer*, 1873, U.S. War Department, pp. 1047–1097.
10. W. J. Petersen, "Cyclones, Windstorms, Tornadoes," *Palimpsest*, vol. 40, Dec. 1959, pp. 529–530.
11. J. J. Sherman, "The Pomeroy Cyclone," *Palimpsest*, vol. 7, June 1926, pp. 172–183.
12. H. R. Spohn and P. J. Waite, "Iowa Tornadoes, 1890–1960; A Chronological County Index by Point of Origin" (unpublished map), 1961.
13. State of Iowa, "Iowa Weather Report," Des Moines, Iowa, 1876–1890.
14. U.S. Weather Bureau, "Tornado Occurrences in the United States," *Technical Paper* No. 20, Washington, D.C., Rev. 1960, 71 pp.
15. U.S. Weather Bureau, *Monthly Weather Review*, June 1921–December 1949, incl.
16. U.S. Weather Bureau, *Report of the Chief of the Weather Bureau*, Washington, D.C., 1916–34.
17. U.S. Weather Bureau, *United States Meteorological Yearbook*, Washington, D.C., 1935–49.
18. U.S. Weather Bureau, *Climatological Data, Iowa*, 1891–1960.
19. U.S. Weather Bureau, *Climatological Data, National Summary*, Washington, D.C., 1950–59.
20. U.S. Weather Bureau, "Tornadoes 1916–1961," L.S. 5913, rev. April 1962.
21. Dorothy Wagner, "The Camanche Tornado," *Palimpsest*, vol. 14, Apr. 1933, pp. 137–148.
22. P. J. Waite and H. R. Spohn, "Tornadoes in Iowa" (unpublished tabulation), 1960.
23. Gen. James B. Weaver, *Past and Present of Jasper County, Iowa*, B. F. Bowen and Co., Indianapolis, Ind., 1912.